

APPENDICES A & B

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United States Patent Application

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for

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**METHODS AND APPARATUS FOR IDENTIFYING RELATED NODES  
IN A DIRECTED GRAPH HAVING NAMED ARCS**

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## Appendix A

### RDF Rules:

From the following definitions:

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Any nodes matching criteria are valid nodes.

All ancestors of a valid node are valid.

All descendants of a valid node are valid, unless they share a predicate with an already valid descendant.

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We get the following rules:

#### Criteria Rules

- Match criteria to triple facts in knowledge base.
- Literals are matched on predicate and object (literal)
- Resources are matched on predicate (only if supplied in criteria) and object (resource)

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#### Sibling Rules

- Finds other valid triple facts at the same level.
- All siblings of a valid node (triples that share the same subject) are valid, unless they have the same predicate as a criteria predicate.

#### Ancestor Rules

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- Backward chaining up the directed graph to find triple facts from valid nodes and criteria
- All ancestors (triples whose object is equal to the subject of the matched triple) of a valid triple are valid, unless there is criteria that negates the subject resource of that triple.
- i.e. Walk up the tree.

#### Decendant Rules

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- Forward chaining down the directed graph to find triple facts from valid nodes and criteria
- Any descendants of a valid triple or root node are valid unless they share a predicate name with a matched triple or criteria.

An example:

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Given the following Original Model

```
<?xml version="1.0"?>
```

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns="http://metatomix.com/rules_test/1.0#">
```

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```
<rdf:Description rdf:about="company://id#3">
  <customer rdf:resource="company://id#1"/>
  <customer rdf:resource="company://id#4"/>
  <customer rdf:resource="company://id#2"/>
```

</rdf:Description>

<rdf:Description rdf:about="company://id#1">  
 <employee>Howard</employee>  
 <employee>Alan</employee>  
 <cto>Colin</cto>

5 </rdf:Description>

<rdf:Description rdf:about="company://id#4">  
 </rdf:Description>

<rdf:Description rdf:about="company://id#2">  
 <employee>David</employee>  
 <cto>Colin</cto>

10 </rdf:Description>

</rdf:RDF>

Generates the following Knowledge Base Facts:

15	Subject	Predicate	Object
	1 company://id#3	http://metatomix.com/rules_test/1.0#customer	company://id#1
	2 company://id#3	http://metatomix.com/rules_test/1.0#customer	company://id#4
	3 company://id#3	http://metatomix.com/rules_test/1.0#customer	company://id#2
	4 company://id#1	http://metatomix.com/rules_test/1.0#employee	Howard
	5 company://id#1	http://metatomix.com/rules_test/1.0#employee	Alan
20	6 company://id#1	http://metatomix.com/rules_test/1.0#cto	Colin
	7 company://id#2	http://metatomix.com/rules_test/1.0#employee	David
	8 company://id#2	http://metatomix.com/rules_test/1.0#cto	Colin

Given the following criteria:

25 Criteria: Employee is Alan

<?xml version="1.0"?>  
 <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" xmlns="http://metatomix.com/rules\_test/1.0#">  
 <rdf:Description rdf:about="criteria://subject">  
 <employee>Alan</employee>  
 30 </rdf:Description>  
 </rdf:RDF>

Rules Fired:

35 Rule 0 - Lit Criteria: Subject: company://id#1 Predicate: employee Object: Alan  
 Rule 1 - Siblings: Subject: company://id#1 Predicate: cto Object: Colin  
 Rule 2 - Ancestors: Subject: company://id#3 Predicate: customer Object: company://id#1

Triples generated:

Subject	Predicate	Object
criteria://subject	http://metatomix.com/rules_test/1.0#employee	Alan
1 company://id#3	http://metatomix.com/rules_test/1.0#customer	company://id#1
2 company://id#1	http://metatomix.com/rules_test/1.0#employee	Alan
5 3 company://id#1	http://metatomix.com/rules_test/1.0#cto	Colin

Output RDF:

```

10 <rdf:RDF
  xmlns:rdf='http://www.w3.org/1999/02/22-rdf-syntax-ns#'
  xmlns:NS0='http://metatomix.com/rules_test/1.0#'
  >
  <rdf:Description rdf:about='company://id#3'>
    <NS0:customer rdf:resource='company://id#1'>
  </rdf:Description>
  <rdf:Description rdf:about='company://id#1'>
    <NS0:employee>Alan</NS0:employee>
    <NS0:cto>Colin</NS0:cto>
  15 </rdf:Description>
  </rdf:RDF>

```

Criteria: CTO is Colin

```

20 <?xml version="1.0"?>
  <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" xmlns="http://metatomix.com/rules_test/
  1.0#">

  <rdf:Description rdf:about='criteria://subject'>
    <cto>Colin</cto>
  </rdf:Description>
  25 </rdf:RDF>

```

Rules Fired:

```

30 Rule 0 - Lit criteria: Subject: company://id#1 Predicate: cto Object: Colin
  Rule 1 - Siblings: Subject: company://id#1 Predicate: employee Object: Alan
  Rule 1 - Siblings: Subject: company://id#1 Predicate: employee Object: Howard
  Rule 2 - Ancestors: Subject: company://id#3 Predicate: customer Object: company://id#1
  Rule 0 - Lit criteria: Subject: company://id#2 Predicate: cto Object: Colin
  Rule 1 - Siblings: Subject: company://id#2 Predicate: employee Object: David
  Rule 2 - Ancestors: Subject: company://id#3 Predicate: customer Object: company://id#2

```

35 Triples generated:

Subject	Predicate	Object
criteria://subject	http://metatomix.com/rules_test/1.0#cto	Colin

1	company://id#3	http://metatomix.com/rules_test/1.0#customer	company://id#1
2	company://id#3	http://metatomix.com/rules_test/1.0#customer	company://id#2
3	company://id#1	http://metatomix.com/rules_test/1.0#employee	Howard
4	company://id#1	http://metatomix.com/rules_test/1.0#employee	Alan
5	company://id#1	http://metatomix.com/rules_test/1.0#cto	Colin
6	company://id#2	http://metatomix.com/rules_test/1.0#employee	David
7	company://id#2	http://metatomix.com/rules_test/1.0#cto	Colin

Output RDF:

```

10 <rdf:RDF
  xmlns:rdf='http://www.w3.org/1999/02/22-rdf-syntax-ns#'
  xmlns:NS0='http://metatomix.com/rules_test/1.0#'
  >
  <rdf:Description rdf:about='company://id#3'>
    <NS0:customer rdf:resource='company://id#1'>
    <NS0:customer rdf:resource='company://id#2'>
  </rdf:Description>
  <rdf:Description rdf:about='company://id#2'>
    <NS0:cto>Colin</NS0:cto>
    <NS0:employee>David</NS0:employee>
  </rdf:Description>
  <rdf:Description rdf:about='company://id#1'>
    <NS0:cto>Colin</NS0:cto>
    <NS0:employee>Alan</NS0:employee>
    <NS0:employee>Howard</NS0:employee>
  </rdf:Description>
20 </rdf:RDF>

```

Criteria: Company is Company1

```

25 <?xml version="1.0"?>
  <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" xmlns="http://metatomix.com/rules_test/
    1.0#">
    <rdf:Description rdf:about='criteria://subject'>
      <criteria://predicate rdf:resource="company://id#1"/>
    </rdf:Description>
30 </rdf:RDF>

```

Rules Fired:

```

Rule 0 - Res criteria: Subject: company://id#3 Predicate: customer Object: company://id#1
Rule 3 - decendents: Subject: company://id#1 Predicate: cto Object: Colin
Rule 3 - decendents: Subject: company://id#1 Predicate: employee Object: Alan
35 Rule 3 - decendents: Subject: company://id#1 Predicate: employee Object: Howard

```

Triples generated:

Subject	Predicate	Object
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	criteria://subject	criteria://predicate	company://id#1
1	company://id#3	http://metatomix.com/rules_test/1.0#customer	company://id#1
2	company://id#1	http://metatomix.com/rules_test/1.0#employee	Howard
3	company://id#1	http://metatomix.com/rules_test/1.0#employee	Alan
5 4	company://id#1	http://metatomix.com/rules_test/1.0#cto	Colin

Output RDF:

```

10 <rdf:RDF
  xmlns:rdf='http://www.w3.org/1999/02/22-rdf-syntax-ns#'
  xmlns:NS0='http://metatomix.com/rules_test/1.0#'
  >
    <rdf:Description rdf:about='company://id#3'>
      <NS0:customer rdf:resource='company://id#1' />
    </rdf:Description>
    <rdf:Description rdf:about='company://id#1'>
      <NS0:cto>Colin</NS0:cto>
      <NS0:employee>Alan</NS0:employee>
15   <NS0:employee>Howard</NS0:employee>
    </rdf:Description>
  </rdf:RDF>

```

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## Appendix B

CTO is Colin

\*\*\*\*\* Criteria Model \*\*\*\*\*

<rdf:RDF

xmlns:rdf='http://www.w3.org/1999/02/22-rdf-syntax-ns#'

xmlns:NS0='http://m.com#'

>

<rdf:Description rdf:about='criteria://subject'>

<NS0:cto>Colin</NS0:cto>

</rdf:Description>

</rdf:RDF>

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f-0 (MAIN::triple (obj "Alan") (objIsRes FALSE) (pred "http://m.com#employee") (subj "company://id#1") )

f-1 (MAIN::triple (obj "company://id#2") (objIsRes TRUE) (pred "http://m.com#customer") (subj "company://id#3") )

f-2 (MAIN::triple (obj "Colin") (objIsRes FALSE) (pred "http://m.com#cto") (subj "company://id#2") )

f-3 (MAIN::triple (obj "Colin") (objIsRes FALSE) (pred "http://m.com#cto") (subj "company://id#1") )

f-4 (MAIN::triple (obj "David") (objIsRes FALSE) (pred "http://m.com#employee") (subj "company://id#2") )

f-5 (MAIN::triple (obj "Howard") (objIsRes FALSE) (pred "http://m.com#employee") (subj "company://id#1") )

f-6 (MAIN::triple (obj "company://id#4") (objIsRes TRUE) (pred "http://m.com#customer") (subj "company://id#3") )

f-7 (MAIN::triple (obj "company://id#1") (objIsRes TRUE) (pred "http://m.com#customer") (subj "company://id#3") )

f-8 (MAIN::criteria (obj "Colin") (objIsRes FALSE) (pred "http://m.com#cto") (subj "criteria://subject") )

For a total of 9 facts.

FIRE 1 MAIN::lit-criteria-rule f-8, f-3

==> f-9 (MAIN::valid-triple (subj "company://id#1") (pred "http://m.com#cto") (obj "Colin"))

==> Activation: MAIN::siblings-rule : f-9, f-8, f-0

==> Activation: MAIN::siblings-rule : f-9, f-8, f-5

==> Activation: MAIN::ancestors-rule : f-9, f-8, f-7

<== f-3 (MAIN::triple (obj "Colin") (objIsRes FALSE) (pred "http://m.com#cto") (subj "company://id#1") )

FIRE 2 MAIN::ancestors-rule f-9, f-8, f-7

==> f-10 (MAIN::valid-triple (subj "company://id#3") (pred "http://m.com#customer") (obj "company://id#1"))

==> Activation: MAIN::decendents-rule : f-10, f-8, f-0

==> Activation: MAIN::decendents-rule : f-10, f-8, f-5

==> Activation: MAIN::root-node-rule : f-10,,

<== f-7 (MAIN::triple (obj "company://id#1") (objIsRes TRUE) (pred "http://m.com#customer") (subj "company://id#3") )

FIRE 3 MAIN::root-node-rule f-10,,

==> f-11 (MAIN::root-node (obj "company://id#3"))

FIRE 4 MAIN::decendents-rule f-10, f-8, f-5

==> f-12 (MAIN::valid-triple (subj "company://id#1") (pred "http://m.com#employee") (obj "Howard"))

<== f-5 (MAIN::triple (obj "Howard") (objIsRes FALSE) (pred "http://m.com#employee") (subj "company://id#1") )

<== Activation: MAIN::siblings-rule : f-9, f-8, f-5

FIRE 5 MAIN::decendents-rule f-10, f-8, f-0

==> f-13 (MAIN::valid-triple (subj "company://id#1") (pred "http://m.com#employee") (obj "Alan"))

<== f-0 (MAIN::triple (obj "Alan") (objIsRes FALSE) (pred "http://m.com#employee") (subj "company://id#1"))

<== Activation: MAIN::siblings-rule : f-9, f-8, f-0

FIRE 6 MAIN::lit-criteria-rule f-8, f-2

==> f-14 (MAIN::valid-triple (subj "company://id#2") (pred "http://m.com#cto") (obj "Colin"))

5 ==> Activation: MAIN::siblings-rule : f-14, f-8, f-4

==> Activation: MAIN::ancestors-rule : f-14, f-8, f-1

<== f-2 (MAIN::triple (obj "Colin") (objIsRes FALSE) (pred "http://m.com#cto") (subj "company://id#2"))

FIRE 7 MAIN::siblings-rule f-14, f-8, f-4

==> f-15 (MAIN::valid-triple (subj "company://id#2") (pred "http://m.com#employee") (obj "David"))

==> Activation: MAIN::ancestors-rule : f-15, f-8, f-1

10 <== f-4 (MAIN::triple (obj "David") (objIsRes FALSE) (pred "http://m.com#employee") (subj "company://id#2"))

FIRE 8 MAIN::ancestors-rule f-15, f-8, f-1

==> f-16 (MAIN::valid-triple (subj "company://id#3") (pred "http://m.com#customer") (obj "company://id#2"))

<== f-1 (MAIN::triple (obj "company://id#2") (objIsRes TRUE) (pred "http://m.com#customer") (subj "company://id#3"))

15 <== Activation: MAIN::ancestors-rule : f-14, f-8, f-1

Final Facts in Knowledge base:

f-6 (MAIN::triple (obj "company://id#4") (objIsRes TRUE) (pred "http://m.com#customer") (subj "company://id#3"))

f-8 (MAIN::criteria (obj "Colin") (objIsRes FALSE) (pred "http://m.com#cto") (subj "criteria://subject"))

20 f-9 (MAIN::valid-triple (subj "company://id#1") (pred "http://m.com#cto") (obj "Colin"))

f-10 (MAIN::valid-triple (subj "company://id#3") (pred "http://m.com#customer") (obj "company://id#1"))

f-11 (MAIN::root-node (obj "company://id#3"))

f-12 (MAIN::valid-triple (subj "company://id#1") (pred "http://m.com#employee") (obj "Howard"))

f-13 (MAIN::valid-triple (subj "company://id#1") (pred "http://m.com#employee") (obj "Alan"))

f-14 (MAIN::valid-triple (subj "company://id#2") (pred "http://m.com#cto") (obj "Colin"))

f-15 (MAIN::valid-triple (subj "company://id#2") (pred "http://m.com#employee") (obj "David"))

f-16 (MAIN::valid-triple (subj "company://id#3") (pred "http://m.com#customer") (obj "company://id#2"))

25 For a total of 10 facts.

\*\*\*\*\* Working Model \*\*\*\*\*

<rdf:RDF

xmlns:rdf='http://www.w3.org/1999/02/22-rdf-syntax-ns#'

xmlns:NS0='http://m.com#'

>

30 <rdf:Description rdf:about='company://id#3'>

<NS0:customer rdf:resource='company://id#1'>

<NS0:customer rdf:resource='company://id#2'>

</rdf:Description>

<rdf:Description rdf:about='company://id#2'>

<NS0:cto>Colin</NS0:cto>

<NS0:employee>David</NS0:employee>

</rdf:Description>

35 <rdf:Description rdf:about='company://id#1'>

<NS0:cto>Colin</NS0:cto>

<NS0:employee>Howard</NS0:employee>

<NS0:employee>Alan</NS0:employee>

</rdf:Description>

</rdf:RDF>

\*\*\*\*\*